

Spatial Specialization and Farm-Nonfarm Linkages

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Abstract

Using individual level employment data from Bangladesh, this paper presents empirical evidence on the relative importance of farm and urban linkages for rural nonfarm employment. The econometric results indicate that high return wage work and self-employment in nonfarm activities cluster around major urban centers. The negative effects of isolation on high return wage

work and on self-employment are magnified in locations with higher agricultural potential. The low return nonfarm activities respond primarily to local demand displaying no significant spatial variation. The empirical results highlight the need for improved connectivity of regions with higher agricultural potential to urban centers for nonfarm development in Bangladesh.

This paper—a product of the Sustainable Rural and Urban Development Team, Development Research Group—is part of a larger effort in the department to understand the impact infrastructure on the pattern of nonfarm employment in developing countries. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at fshilpi@worldbank.org.

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1 Introduction

What drives growth in rural nonfarm activities? This has been a key concern of policy makers and development economists in recent years (Lanjouw and Lanjouw, 2001; Lanjouw and Feder, 2001; Haggblade, Hazell and Reardon, 2006). This is not surprising in light of the empirical evidence that non-farm activities have emerged as a major source of income and employment in many developing countries especially for the asset-poor rural population. Various surveys of existing evidence highlighted two stylized facts about the pattern of nonfarm development in rural areas. First, these activities seem to thrive in areas experiencing higher agricultural growth (Haggblade, Hazell and Reardon, 2002). Second, a large chunk of these activities are located in and around towns and cities (Renkow, 2006). The empirical literature on non-farm activities, while recognizing the importance of both farm and urban linkages, has tended to examine them in isolation. Using a simple conceptual framework which combines these separate approaches to examining urban and farm linkages, this paper sheds some light on the relative strength of these two forces in determining employment in different types of nonfarm activities.

Because of its focus on both farm and urban linkages, two strands of literature are directly relevant for the empirical analysis of this paper. Perhaps the most predominant view among development practitioners about non-farm development is that growth of nonfarm activities in rural areas is driven primarily by agricultural productivity growth at least at the initial stage (Mellor, 1976; Ranis and Stuart, 1973, Haggblade, Hazell and Reardon, 2006; Johnson, 2000). Various production, consumption and labor market linkages, according to this view, tie the development of nonfarm and farm sectors together, leading to multiplier effects of productivity growth in agriculture.

Because of its obvious policy implications, early empirical studies on nonfarm activities de-

voted significant attention to identifying different factors that can strengthen the farm-nonfarm inter-linkages (see, Lanjouw and Feder, 2001 for a survey). Empirical evidence from this early literature demonstrated the presence of a positive and significant correlation between farm and nonfarm income and employment, and highlighted the importance of rural roads in augmenting these inter-linkages (Hazell and Haggblade, 1990; Hazell et. al, 1991; Lewis and Thorbecke, 1992).¹ A pair of recent studies by Foster and Rosenzweig (2004 a and b), however, raised some doubts about the universality of a positive correlation between farm productivity and non-farm employment/income. Utilizing a rigorous empirical methodology and a panel dataset from India, these studies find that only non-tradeable nonfarm activities such as services are positively influenced by agricultural productivity growth. In contrast, tradeable nonfarm activities such as small manufacturing move into areas with lower wages implying a negative relationship with agricultural productivity growth.² This particular pattern of nonfarm growth, according to Foster and Rosenzweig (2004a), had contributed significantly to reducing spatial wage inequality and overall poverty in India. Although these studies mentioned possible influence of rural towns on non-farm activities, none has explored effects of larger urban centers on the location of such activities.

The second insight into the evolution of nonfarm activities comes from the literature on urban-rural linkages, particularly from traditional and so-called *new* economic geography. According to this work, urban demand exerts a distinct influence on the types of activities that take place in rural areas (von Thünen, 1842; Fujita, Krugman and Venables, 1999; Henderson, Shalizi and Venables 2001; Renkow, 2006). The inter-play of agglomeration economies and congestion dis-economies, according to this view, determines location of activities over space re-

¹It should be noted that because of their reliance on primarily cross-section, and to some extent pooled data, and of their inability to address the targeting of road infrastructure, the positive correlation between farm and non-farm income and employment found in these studies do not necessarily establish any causal relationship.

²Harris (1987) reported similar findings with respect to manufacturing located in rural towns in India.

sulting in distinct regional patterns centering around large urban centers. These distinct patterns of specialization characterize not only farming but also different types of nonfarm activities.

A number of recent studies have demonstrated empirically the presence of such zones of specialization in rural areas. For instance, Fafchamps and Shilpi (2003), using household level data from Nepal, find that both wage and self-employment in nonfarm activities are heavily concentrated in close proximity to large urban centers and somewhat concentrated around local markets.³ Fafchamps and Shilpi (2005) report a significant effect of proximity to cities on rural diversification and specialization along with the presence of some agglomeration economies around the cities. However, none of these studies analyzed the possible feed-back from agriculture to nonfarm activities.

The main objective of this paper is to examine whether and how the farm and urban linkages *jointly* shape the spatial pattern of non-farm activities observed in the context of a developing country, Bangladesh. To this end, we develop an empirical framework which combines these two separate approaches to examining urban-rural and farm-nonfarm linkages. The use of a comprehensive framework incorporating both types of inter-linkages helps to portray much richer picture of the effect of infrastructure on non-farm activities. Better infrastructure can lead to a relocation of tradeables to cities and towns, reducing the density of such activities in rural areas. By extending the size of the market, better infrastructure, on the other hand, can facilitate agricultural productivity growth and induce growth of nonfarm activities in rural locations⁴. The overall impact of better infrastructure will thus depend on the relative strength and interaction of these inter-linkages.⁵

³ Although the study uses cross-section data, it utilizes an instrumental variables approach to correct for endogenous placement of roads.

⁴ The rural areas may attract more nonfarm activities as a result of infrastructure improvement if cities or towns are too congested and have higher living costs.

⁵ Agricultural productivity, by affecting rural wages, can also trigger relocation of non-farm activities over space.

Our empirical analysis uses individual level employment data from the Household Expenditure and Income Survey (HIES, 2000) of Bangladesh. With high incidence of rural poverty and an ever dwindling supply of agricultural land, growth in nonfarm activities is perhaps the best hope for development in this densely populated country.⁶ Bangladesh lies at the confluence of three of the largest rivers in Asia, Ganges-Brahmaputra-Meghna, which have virtually sliced the country into four distinct and poorly integrated geographical regions. These regions differ considerably in terms of their agricultural potential and infrastructure development, which make Bangladesh particularly suitable for our analysis.

In our empirical specification, farm linkages are captured by a crop suitability index developed by agricultural scientists. The use of this crop suitability index, determined by inherent land and water quality as well as climatic condition of a locality, helps to avoid the potential endogeneity problems that arise when farm income/productivity/employment is used as a regressor. The urban linkage is proxied by an index of access to urban centers which is measured by the minimum arc distance from the surveyed primary sampling units to either of the two main cities - Dhaka and Chittagong.⁷ This distance variable thus represents access to national and international markets (Dhaka being the capital city and main airport, and Chittagong, the main port city). It should be noted that this distance measure does not depend on the actual placement of transport infrastructure. Use of this access variable in the estimation helps to avoid the potential endogeneity of more commonly utilized urban access regressors such as travel times.

Because of the heterogeneity of non-farm activities, we also make the distinction between

⁶More than half of Bangladesh's nearly 100 million rural residents still live in poverty. With nearly 1000 people per square kilometer, population density in Bangladesh is among the highest in the world. Non-farm activities have already assumed an important role in the rural economy, accounting for nearly 42 percent of total rural employment and more than half of rural household income (World Bank, 2004).

⁷This distance is estimated using the Haversine formula. In addition to this urban access variable, the regression analysis also controls for proximity to smaller towns, which is found to be not important.

different types of non-farm activities (high return, low return wage work, self-employment). The motivation for this classification of nonfarm activities comes from the fact that not all nonfarm activities offer returns higher than agriculture (Lanjouw and Feder, 2001; Haggblade, Hazell and Reardon, 2006).⁸ In almost all developing countries, a substantial fraction of individuals and households are engaged in non-farm activities that earn less than median agriculture wage. Growth in the relatively high return non-farm activities is what is needed for rural income growth and poverty reduction. Thus from a policy point of view, it is important to assess the role of urban and farm linkages in spurring growth in different types of non-farm activities especially the relatively high return non-farm activities.

The empirical analysis yields three main results. First, proximity to large cities is an important determinant of the nature of nonfarm activities in a region. The likelihood of being employed in high-return nonfarm jobs, which pay more than median agricultural wage, increases with a decrease in distance from the growth poles (Dhaka and Chittagong) suggesting presence of some agglomeration economies. Second, the effect of agricultural potential, measured by cash crop suitability of a village, also depends on how far that village is from the growth poles. The empirical results suggest that the negative effect of isolation (or distance to nearest growth pole) is magnified in locations with higher agricultural potential. Specifically, when the level and interaction effects are combined, we find that the propensity of being employed in high-return wage work and self-employment declines with an increase in distance from growth poles, and declines at a faster rate in regions with higher agricultural potential. The low return wage work, which pays less than or equal to the median agricultural wage of a village, on the other hand, shows no significant relationship with access to growth poles. These jobs seem to cater to local demand

⁸Note that non-farm activities can be classified by occupations and sectors. But within each category of the occupations/sectors (for instance, manufacturing), there is wide variation in the rates of return encompassing both low and high return activities (within manufacturing sector).

and are distributed almost evenly over geographical space. Finally, the regression results suggest no significant influence of access to rural towns on any of these three types of activities. When occupational classification of nonfarm activities are examined, only nontradeable services work is found to show some concentration around smaller towns. The empirical results thus highlight the need for improved connectivity of regions with higher agricultural potential to urban centers for stimulating growth in high return wage employment and self-employment in non-farm activities.

The rest of the paper is organized as follows. Section 2 discusses the conceptual framework underpinning the empirical analysis. Section 3 describes the basic features of our data. Section 4 presents the empirical results. The main conclusions are drawn in Section 5.

2 Conceptual Framework

We start our empirical specification with the basic insights from studies on farm-nonfarm linkages. According to this literature, the fates of the agricultural sector and nonfarm activities in rural areas are tied together because of a multitude of production, consumption, labor and capital market linkages. On the production side, a growing agriculture creates backward linkages by stimulating demand for raw materials, equipment and related services, and forward linkages by supplying farm products that need to be processed and distributed. A growing agriculture also boosts demand for rural goods and services produced by nonfarm activities. With growing labor productivity, agriculture releases labor and provides surpluses to nonfarm activities that can be reinvested. On its part, nonfarm activities reduce input costs and help induce technical change in agriculture. This idea of farm-nonfarm linkages is captured in a simple reduced form specification:

$$Y_{ij} = \theta X_{ia} + \gamma Z_{ij} + u_{ij} \quad (1)$$

where Y_{ij} is the employment or income in nonfarm activity j in location i , X_{ia} is the agricultural employment or income in location i , and Z_{ij} is a vector of variables that are relevant for explaining nonfarm employment or income, and u_{ij} is an error term. For instance, Hazell and Haggblade (1990) estimated equation (1) using state and district level data on farm and nonfarm income from India where the vector of variables Z_{ij} included interaction of agricultural income with road density, population density and irrigation. The theoretical model presented in Foster and Rosenzweig (2004a), however, demonstrated the need for distinguishing between different types of nonfarm activities.⁹ The reduced form in Foster and Rosenzweig (2004a & b) relates closely to equation (1) where nonfarm activities include traded manufacturing products and non-traded services. Equation (1) is estimated using both village (focusing on employment) and household (income) level panel data from India. Foster and Rosenzweig (2004a) include village and household level fixed effects in the vector of explanatory variables Z_{ij} to account for unobserved heterogeneity. They instrument for yield growth in agriculture (proxy for X_{ia}) to remedy potential endogeneity problems. In this formulation, the urban influence on location of nonfarm activities is subsumed in the fixed effect and is eliminated when equation (1) is estimated in its first differenced form.

In contrast with the literature on farm-nonfarm linkages, the economic geography literature maintains that economic activity need not spread evenly across geographical space even if land is undifferentiated across locations. Locations of economic activity are characterized by distinct regional patterns which result from the interplay of two opposing forces. Dispersion of economic

⁹The heterogeneity of the nonfarm activities has been discussed widely in the literature on nonfarm activities, for example, see surveys done by Lanjouw and Lanjouw, 2001; Lanjouw and Feder, 2001; Haggblade, Hazell and Reardon, 2006).

activity occurs as producers take advantage of wage differentials, require proximity to sources of raw materials or consumers, if transport costs are prohibitive, or because they require access to immobile factors of production (e.g. land in agriculture). Many services, which represent a large share of nonfarm activities, are non-tradeable and therefore produced and consumed locally. Counteracting these dispersion forces are agglomeration economies that encourage firms to concentrate production in a few places. Sectors that rely on mobile factors of production (capital and labor), that benefit from scale economies and have low transport costs tend to cluster in a limited number of locations—mostly in urban areas. Both traditional and new economic geography theory places cities at the center of the economic landscape and predict distinct patterns of specialization as one moves farther and farther away from cities.¹⁰ The theoretical predictions thus imply systematic relationships between distance from urban centers and types of activities one expects to observe over geographical space. The insights from the economic geography theories can be incorporated in the following reduced form specification:

$$Y_{ij} = f(d_{ik}) + \gamma Z_{ij} + u_{ij} \quad (2)$$

where d_{ik} is some measure of distance between location i and urban center k . Equation (2) allows a flexible functional form with respect to distance and has been applied in several recent empirical studies on geographic specialization in predominantly rural countries (see, for example, Fafchamps and Shilpi, 2003 & 2005, Jacoby, 2000).¹¹ Semi-parametric estimation of equation (2) in Fafchamps and Shilpi (2003 & 2005) demonstrates the importance of location in determining the types of farming and nonfarm activities undertaken in rural areas.

¹⁰For instance, von Thünen (1842) and subsequent modifications of the von Thünen model predict concentric circles of specialization in agriculture surrounding cities. Fafchamps(1997) and Venables and Limao(1999) predict incomplete or partial specialization, again with respect to distances from urban centers.

¹¹Fafchamps and Shilpi(2003 & 2005) also control for the population size of the urban centers.

Extending these studies to control for potential linkages between farm and nonfarm activities, we combine equations (1) and (2):

$$Y_{ij} = f(d_{ik}) + g(X_{ia}) + \gamma Z_{ij} + u_{ij} \quad (3)$$

Equation (3) thus incorporates both urban and farm linkages in a single specification and will form the basis of the empirical evidence discussed in the following sections. Estimation of equation (3) still presents a number of challenges. First, because nonfarm activities can also influence agricultural productivity and employment, there is a potential endogeneity problem in using agricultural productivity or employment as an indicator in X_{ia} . To address this issue, we use a cash crop suitability index as a measure of agricultural potential at a given location. This index is defined by agricultural scientists for each location on the basis of land quality, water availability, and weather conditions. It should be noted that as the geo-physical characteristics of a village are extremely slow to change, this index is also relatively time invariant. As agricultural development involves productivity growth in cereals crops and increasing diversification into non-cereal and cash crops, we used the cash crop suitability index as a measure of agricultural potential. The robustness checks in the later sections indicate that our basic results remain unchanged if we use an overall crop suitability index.

The second problem in the econometric estimation relates to the definition of access to urban centers. Because there are many different cities and towns of varying sizes, it is often difficult to identify relevant metrics in defining the access variable. Foster and Rosenzweig (2004b), for instance, used a dummy for any village location within 10 kilometers of a town.¹² Evidence in Fafchamps and Shilpi (2003 & 2005), on the other hand, suggests that access to larger cities has

¹²Much of the earlier literature on rural nonfarm activities also report concentration of these activities in rural towns and smaller cities. The larger urban centers in this literature are viewed mostly as competitors to rural activities (see, Haggblade, Hazell, and Brown, 1984).

a relatively more significant effect on spatial patterns of specialization. This will be particularly true in less developed countries where poor infrastructure endowment has led to a concentration of economic and political functions in one or very few large urban centers (e.g., Henderson, 2002). We control for two types of accessibility in our regressions: access to nearest town or urban municipality with a population of at least 5000 inhabitants,¹³ and access to the two major growth poles in the country. In Bangladesh, the capital city Dhaka and the port city of Chittagong in the Southeast are the primary urban centers, accounting for a large share of urban and overall population¹⁴. They act as the main domestic and international trading hubs and are the dominant seats of major administrative and economic functions. The travel time to urban centers is often taken as the indicator of accessibility in the existing literature (see for example, Fafchamps and Shilpi, 2003; Jacoby, 2000). The use of travel time in defining access to urban centers raises concerns about the possible endogeneity in the placement of road infrastructure (van de Walle, 2002).¹⁵ In order to avoid the potential endogeneity problem of travel time, we use minimum arc distance from surveyed primary sampling units to either of the two metropolitan centers (Dhaka or Chittagong) as an indicator of accessibility. These distances are estimated using the Haversine formula. These distances, popularly known as the crow fly distances, do not depend on the actual placement of road and other transport infrastructure. Yet, they provide good measures of the geographical dispersion of the surveyed locations with respect to Dhaka and Chittagong.

In order to complete the econometric specification, next we define our dependent variable. There is considerable evidence on the heterogeneity of non-farm activities consisting of high and

¹³This measure of access to towns is used in the regression mainly to conform with existing literature. It should also be noted that using access to other towns of larger sizes (e.g. 10,000 inhabitants) do not change the results significantly.

¹⁴Population in these cities accounts for 87 percent of total population in metropolitan cities, and 48 percent of total urban population in the country.

¹⁵Roads are often built in areas with greater agricultural and perhaps also nonfarm potential.

low return activities, of tradeable and nontradeable activities, and of different types of occupational categories in the existing literature (Ranis and Stuart, 1973; Lanjouw and Feder, 2001, Haggblade, Hazell and Reardon, 2006). This is confirmed in the context of Bangladesh, where nearly 39 percent of non-farm worker are engaged in a myriad of service related occupations. Among different subsectors, a quarter of nonfarm workers are employed in manufacturing. In this paper, we focus mainly on the distinction between high and low wage employment and self-employment in the non-farm sector. Motivation for this classification of the non-farm activities is derived from the evidence that in every developing country, a substantial segment of the non-farm activities offer returns that are lower than the agriculture wages. For instance, in Bangladesh, about 28% of the wage workers in the nonfarm sector earn less than the median agricultural wage rate, These types of nonfarm activities may ensure bare subsistence, but they by no means offer an escape from poverty. What drives the growth of the relatively high return non-farm activities is thus a more pertinent issue from the policy perspective.

Standard occupational and sectoral classification of the non-farm activities can not be used to distinguish between high and low return activities. Table 1 reports the broad occupational and sectoral classifications of non-farm activities by types of non-farm employment (high return, low return and self-employment) using the HIES 2000 data from Bangladesh. The high return wage works are defined as those activities which pay more than the median agricultural wage in the locality and vice versa. Of all services workers, 18 percent are engaged in low return wage employment, 43 percent in high return wage employment and 35 percent in self-employment. Services workers predominate in all three types of employment (high return, low return and self-employment). For instance, 45 percent of all low return wage employment, 37 percent of high return wage employment and 39 percent of self-employed are engaged in services occupations. Similar patterns are evident in the case of sectoral classification of non-farm activities with

the exception of sales where self-employment predominates. These patterns are confirmed in the finer classification of occupations and sectors. Evidence in Table 1 thus shows that for both occupational and sectoral classifications of non-farm activities, every sub-category includes a number of activities with returns ranging from below the median agricultural wage to well above median agriculture wage rates. Analysis based on these classifications is likely to be less informative in highlighting the role of farm and urban linkages in stimulating pro-poor nonfarm growth.

For the empirical analysis, we define our dependent variable as the employment status of an individual where the status variable indicates multiple choices. Specifically, the dependent variable takes the value of 1 if an individual is employed in agriculture (our base outcome), 2 if employed in low-return wage employment in the nonfarm sector, 3 if employed in high return wage jobs in the non-farm sector; and 4 if self employed in the non-farm sector. The high return nonfarm jobs are defined as those activities which pay higher than median agricultural wage in the village. The low return nonfarm jobs are those that pay less than or equal to median agricultural wage. We also test robustness of our econometric results using other definitions of nonfarm activities (e.g. production workers vs service workers) as suggested by Foster and Rosenzweig (2003a & b). Since the dependent variable includes unordered multinomial responses, we use standard multinomial logit estimation technique for the empirical analysis.

3 The Data

The main data source for our empirical analysis is the Household Income and Expenditure Survey (HIES) 2000 of Bangladesh. The survey drew a nationally representative sample of 7440 households in 442 primary sampling units (PSUs) which are equivalent to census enumeration areas. It also contains detailed information on about 39,000 individuals including data on

income, expenditures and employment. A community questionnaire was administered for the rural PSUs. The initial survey did not collect information on the precise geographic location of each cluster which would allow integration of survey data with other spatially referenced information. Instead, we took advantage of a highly detailed map of enumeration areas in Bangladesh to identify the location of the centroid of each survey PSU.¹⁶

While the survey provided a large number of explanatory variables at individual, household and community levels, it lacked information on the agricultural endowment of survey locations. We derived this information from a spatial database of crop suitability that was constructed by UN-FAO and the Bangladesh Agricultural Research Council as part of a project to develop a database of agroecological zones (AEZs) in Bangladesh (FAO/BARC, 1998). The crop suitability index was developed by agricultural scientists by taking into account individual crop characteristics, input/management levels, the soil's physical characteristics, hydrologic and climatic conditions, and seasonal variability.¹⁷ In developing this index, attributes of each of Bangladesh's 486 Thanas or districts are rated on a scale of 1 to 5 and the index is defined for 48 different crops. In this analysis we use an average suitability of nine major cash crops.¹⁸ We also check robustness of our result using an index of all crop suitability.¹⁹

Out of about 39,000 individuals in HIES 2000, about 40 percent are children (less than 15 years of age). Another 32 percent reside in urban areas. This leaves a sample of 6,828 individuals residing in 248 PSUs who reported their primary occupation. The summary statistics for the variables that are included in the empirical analysis are reported in appendix Table A.1. Nonfarm activities account for about 48 percent of total employment in rural areas. Among all employed

¹⁶This task was implemented by the Center for Environmental and Geographic Information Services in Dhaka, Bangladesh.

¹⁷The crop suitability index is the result of the interactions of as many as eleven important soil factors together with the moisture and thermal regimes of the climatic factor. See BARC website for details.

¹⁸These include jute, tea, sugarcane, cotton, potato, yam, nuts, hemp and berry.

¹⁹This index rates the suitability of each location for cereal, pulses, vegetables, fruits and cash crop production.

persons, 21 percent are employed in high returns wage work which pays better than the median agricultural wage rate of the PSU, and another 8 percent are employed in low return activities. Self employment in nonfarm activities accounts for 18 percent of total employment. Among different occupational categories, services workers dominate accounting for 18 percent of total employment, followed by unskilled production work (16 percent).

The summary statistics in table A.1 show that the median arc distance to the nearest growth pole is about 121 kilometers (km) and the average is 135 km. The closest PSU is just 1 km away whereas the farthest is 367 km away. The nearest town with population of 5000 or more is on average about 43 km away. The average cash crop suitability index is shown in Figure 1. The North-Western part of the country ranks high in terms of crop production potential. The cash crop suitability index ranges from 2.2 (low) to 4.8 (high) with an average of 3.44 and median of 2.70 (Table A.1). The all crop suitability index shows patterns similar to cash crop suitability index. The summary statistics for all other variables included in the regressions are reported in appendix Table A.1.

4 Empirical Results

4.1 Preliminary Evidence

We follow a step by step procedure to present regression results to demonstrate the robustness of empirical findings of this paper. We start by presenting simple multinomial logit regression results while ignoring any possible non-linear effects. All regressions reported in this paper include a number of individual, household and village specific regressors. Specifically, the regressions include controls for age, gender and education of an individual. At the household level, they include household size, ownership of land and asset, and whether it has an electricity connection

as regressors. Village level controls consist of a number of dummy variables indicating if the village has electricity, NGO programs, credit programs, and a market. In addition, distance to nearest town with population more than 5,000 is also included as a regressor. All standard errors are also corrected for within cluster correlations and heteroskedasticity. While we focus on the discussion of main results with respect to urban access and agricultural potential, Appendix Table A.2 provides the full results from regressions corresponding to the specification in columns designated as 1 in Table 2.

The marginal effects from the multinomial logit regressions corresponding to equation 1, 2 and 3 are presented in column 1 to 3 respectively of Table 2. The distance to the nearest growth pole is expressed in natural logarithms and assumed to enter into equation 2 and 3 as a linear term. The regression results for the specification in equation (1) show that cash crop suitability has a negative coefficient in the regression for all types of nonfarm activities. The coefficient is highly significant in the case of high return wage work and self-employment. The estimated coefficients imply that the probability of being employed in high return wage work and self-employment is much lower in regions with high cash crop production potential. This result for high return nonfarm activities is consistent with the findings of Foster and Rosenzweig (2003a & b) who reported a negative impact of agricultural productivity growth on nonfarm factory employment. Although Foster and Rosenzweig (2004a) did not analyze self-employment in nonfarm activities, they report a positive relationship between nonfarm business income and agricultural productivity growth at the household level. The negative correlation between probability of being self-employed and crop suitability thus seems to be contrary to the findings of Foster and Rosenzweig (2004a).

Columns designated as (2) in Table 2 report the regression results from specification in equation (2) where the distance variable enters into the regression as a linear term. The

marginal effect of distance to the nearest growth pole estimated at the mean is negative and statistically highly significant in the case of high return wage work. This implies that the probability of being employed in the high return nonfarm sector declines significantly with an increase in distance to the nearest growth pole. In the case of self-employment, the effect is negative but slightly smaller in magnitude compared with high return wage employment. In contrast, low return wage work seems to have no significant correlation with distance from urban centers. These results are consistent with the findings of Fafchamps and Shilpi (2003) for Nepal who also reported a concentration of wage work within close proximity of major urban centers.

Columns designated as (3) in Table 2 report the regression results from a linearized specification of equation (3). The results suggest a significant effect of access to the two major urban centers for high return nonfarm wage work and self-employment. The crop suitability, however, is statistically significant at 5 percent level with a negative sign in the case of high-return wage work and self-employment. We also included distance to nearest small town as a separate regressor in all regressions. This access to town variable appears to have no significant effect on nonfarm activities once access to urban centers is included as a regressor. While the overall results with respect to the location of nonfarm activities vis-a-vis urban centers are consistent with available evidence, the negative sign of the cash crop suitability index in the regressions raises questions about the role of agricultural linkages in the context of Bangladesh. If the results with respect to cash crop survive further scrutiny, it would imply that non-farm activities tend to concentrate in areas with lower agricultural potential and perhaps lower labor costs. While Foster and Rosenzweig (2004a & b) lend support to this hypothesis in the context of tradeable nonfarm activities, in the following sub-sections, we subject these results to further testing.

4.2 Non-Linearity

The regressions presented in Table 2 ignore possible non-linearity in the impact of access to urban centers and crop suitability. Fafchamps and Shilpi (2003), for instance, report a non-linear impact of distance to urban centers, with nonfarm wage work concentrating in the immediate vicinity of urban centers. Hazell and Haggblade (1990) argued that the impact of agriculture on nonfarm activities also depends on the underlying infrastructure in the region. This infrastructure may be significantly denser in areas immediately surrounding a city. We explore possible non-linearity using non-parametric estimates of the relationship between participation in different types of nonfarm activities and distance to urban centers as well as crop suitability using LOWESS smoothers. The estimated relationships are presented in Figure 2a and b. The relationship between access to growth poles and nonfarm activities in Figure 2a can be roughly approximated by a downward sloping straight line. In the case of crop suitability (Figure 2b), the relationship appears to be slightly concave in the case of high return wage work and self-employment. These patterns suggest that the effect of agricultural potential may depend on infrastructure quality in the region, as hypothesized by Hazell and Haggblade (1990). This may be particularly relevant in the case of Bangladesh where the North-West region of the country is rich in terms of agricultural potential and has historically remained under-developed both agriculturally and in terms of nonfarm activities because of its relative isolation. The horizontal line in the case of low return wage work (Figure 2b) suggests absence of any significant relationship with crop suitability.

Table 3 reports the regression results when various non-linear terms are introduced. The columns numbered as (1) report the results when a squared term of cash crop suitability is added to the specification of equation (1). The results show that because of multicollinearity, neither the crop suitability index nor its squared terms are statistically significant individually

but they are jointly significant in the case of high return wage work and self-employment.²⁰ In both of these cases, the sign of the estimated coefficients implies a concave relationship, similar to the non-parametric regressions. In column (2) we add an interaction of distance and the crop suitability to the specification in equations (2).²¹ In the case of high return nonfarm wage work, both distance term and its interaction with crop suitability index are statistically significant. Both terms are also jointly significant with a P-value=0.00. In the case of self-employment, the distance term has the correct negative sign but it is not precisely estimated. But the interaction term is highly significant and both terms are jointly significant with a P-value=0.001. In the case of low return wage employment, only the interaction term is significant. The marginal effect of distance has a positive sign in the case of low return wage employment and it is not statistically significant even at 10 percent significance level. The final column (3) in the table reports the marginal effects from a specification where crop suitability and its interaction with travel time are introduced as regressors.²² Interestingly, the crop suitability term now has a positive sign and is statistically significant (at 1 percent) in the case of high-return wage work. The interaction term is statistically significant and has a negative sign in the regressions for high return wage employment and self-employment. Overall, the results from this specification are comparable to those from the preceding specification in column numbered (2).

The results from the second column of Table 3 indicate that the impact of access to urban centers depends on the crop potential of a location in the case of high return wage work and self-employment. The probability of being employed in either of these activities declines with

²⁰The collinearity between crop suitability index and its interaction with travel time is particularly severe with a correlation coefficient of 0.90.

²¹We also estimated variants of this specification where crop suitability and its squared terms were introduced in the regression. But none of those terms are statistically significant prompting us to drop them in order to avoid over-parameterization and collinearity problems.

²²We ran a regression where the distance variable was included in addition to crop suitability and its interaction with distance. Severe collinearity renders all the individual terms separately statistically insignificant. To avoid collinearity problems, we dropped the distance variable.

an increase in distance from urban centers. The negative impact of isolation is magnified in regions with higher crop production potential. Similarly, improved crop potential of a location increases the probability of high-return wage work but the effect of crop potential diminishes as one moves farther away from the urban centers. The log-likelihoods of the regressions suggest a slight preference for the second specification (column 2) over other specifications. We therefore further examine the robustness of these results in the following section using this specification.

4.3 Robustness

In order to check the robustness of our results regarding the marginal effects of isolation and agricultural potential, we carry out the estimation using an alternative crop suitability index and an alternative indicator of urban access. The upper panel of Table 4 reports the marginal effects from multinomial logit regression which uses suitability of a location in growing all types of crop (cereals, fruits, vegetables and cash) as an indicator of agricultural potential. The marginal effects of interaction of crop suitability and distance to growth poles are negative and statistically significant at 5 percent level or less in the cases of all different types of non-farm activities. This is consistent with the results reported in column 2 of Table 3. While the distance variable had a statistically significant negative effect in the case of high return wage employment in column 2 of Table 3, the term has now become statistically insignificant (Table 4). However, the joint tests of significance indicates that both terms are highly statistically significant ($p\text{-value}=0.00$). In the case of self-employment, the marginal effect of distance to growth pole has a positive sign and is not statistically significant. But the implied effect of distance is negative when the interaction term is included as the minimum value of the crop suitability index is 2.1. Overall, the results regarding distance and its interaction with crop suitability remain qualitatively similar to those implied by results in column 2 of Table 3.

As an indicator of urban access, we used arc distances from surveyed PSUs to growth poles. Although this measure of access to urban centers is not subject to endogeneity concerns due to targeted road placement, one may still worry about the measurement errors as its estimation completely ignored transport networks. Thus, as a further check of robustness, we used the travel time to growth poles as an indicator of urban access instead of arc distances. The travel times are estimated as road network travel times with some reasonable estimates of travel speeds on a given type of road using geographic information system (GIS) software. The marginal effects from multinomial logit estimation are reported in the lower panel of Table 4. Comparison of results in Table 4 (lower panel) and in column 2 of Table 3 indicates that use of travel time to growth poles as urban access indicator has resulted in an improvement in the precision of estimates in the case of high return wage employment and self-employment. The overall results regarding the effect of urban access and its interaction with agricultural potential, however, remain qualitatively unchanged.

Finally, we examine if our results regarding access to urban centers and crop suitability carry over to other possible definitions of non-farm activities. Using the occupational classification of work, we define two categories of employment. Factory workers are engaged in production work in manufacturing and services workers comprise of all other nonfarm sectors including sales, transport and communication, construction, and so on. These definitions of factory workers (tradeable activity) and services workers (non-tradeable) are comparable to those of Foster and Rosenzweig (2004a). The marginal effects from the multinomial logit estimation are presented in Table 5. The interaction of urban access and crop suitability again has a statistically significant effect on the probability of being employed as factory and services workers. In the case of factory workers, distance to major cities has a negative sign but is statistically significant only at the 10 percent level. In the case of service workers, the marginal effect of distance to growth

pole has the correct negative sign but it is not statistically significant. The estimated marginal effects imply that the probability of being employed as a factory worker and as a service workers declines with an increase in distance from growth poles. The estimates in Table 5 also suggest that services are somewhat concentrated around smaller towns implying importance of local demand in the case of non-traded activities. This finding is similar to that reported in Foster and Rosenzweig (2004a). The results in Table 5 also confirm our earlier finding that the negative effect of isolation is magnified in regions with higher crop production potential.

5 Conclusions

Rural areas, home to most of the world's poor, have experienced considerable employment diversification into nonfarm activities during the last decade. Recognizing its potential for stimulating growth and reducing poverty, there has been a resurgence of interest among researchers and policy makers in identifying factors that can spark growth in the rural nonfarm economy. While the roles of farm and urban linkages in promoting nonfarm activities are discussed frequently by development practitioners, empirical studies examined them in isolation of each other. Embedding the two linkages in a single specification, this paper provides empirical evidence on the relative role of farm and urban linkages in determining the probability of being employed in different types of non-farm activities.

The econometric analysis, using individual level employment data from the Household Income and Expenditure Survey, 2000 of Bangladesh, yields three main results. First, access to major urban centers matters greatly for high-return nonfarm activities. Second, agricultural potential of a village also matters, but through its interaction with access to urban centers. The results specifically suggest that the likelihood of being employed in high return jobs and in self-employment increases with a decrease in distance to growth pole and the negative effect

of isolation is magnified in regions with greater agricultural potential. In contrast, low return nonfarm jobs, paying equal to or less than median agricultural wage of a village, are driven by local demand and are distributed much more evenly across geographical space. Finally, access to smaller rural towns with population of about 5,000 exerts little influence on nonfarm activities except for non-tradeable services work. The empirical results thus highlight the need for improved connectivity of regions with higher agricultural potential to urban centers for stimulating growth in high return wage employment and self-employment in non-farm activities in Bangladesh.

While our empirical analysis is done in the context of Bangladesh, the findings have wider applicability in the context of developing countries. The results highlight the need for examining both farm and urban linkages simultaneously. Since the relative importance of the linkages is likely to vary across countries, country specific estimation of the impact of these linkages will facilitate informed policy making with respect to investment in infrastructure and agriculture development.

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Table 1: Occupational and Sectoral Distribution of Activities by Type of Employment

	Type of Non-farm Employment			% of	
	Wage employment		Self Employment	Total	Total NF Employment
	Low Return	High Return			
Occupations	(%)	(%)	(%)	(%)	
Services workers	18(45)	43(36.5)	35(39)	100	38.6
Production workers	20(38)	48(32.2)	28(24)	100	30.1
Other workers	9(16)	47(31)	43(36)	100	30.3
Total	(100)	(100)	(100)		
% of total NF employment	16.1	47	36.9		
Sectors					
Manufacturing	25(39)	51(28)	24(16)	100	25
Sales	5(8)	13(7)	82(57)	100	26
Transport and construction	14(20)	63(30)	23(14)	100	23
Other	20(33)	63(35)	17(12)	100	26
Total	(100)	(100)	(100)		
% of total NF employment	16.1	47	36.9		

Note: Figure in the parenthesis are percentage of row total.

Table 2: Urban access, Cash crop potential and Non-farm Employment

Dependent variable: Type of Employment in Non-Farm sector	Marginal effects Multinomial Logit regressions		
	(1)	(2)	(3)
<i>Wage employment-Low Return</i>			
Cash Crop Suitability Index	-0.012 (1.84)		-0.014 (2.02)*
Distance to Major cities (log)		0.003 (0.40)	0.007 (0.78)
Distance to towns (KM)	-0.0002 (0.84)	-0.0001 (0.78)	-0.0002 (0.91)
<i>Wage employment-High Return</i>			
Cash Crop Suitability Index	-0.044 (3.59)**		-0.032 (2.56)*
Distance to Major cities (log)		-0.056 (4.76)**	-0.048 (4.10)**
Distance to towns (KM)	-0.001 (1.79)	-0.001 (1.59)	-0.001 (1.66)
<i>Self-Employment</i>			
Cash Crop Suitability Index	-0.040 (2.80)**		-0.034 (2.32)*
Distance to Major cities (log)		-0.031 (2.79)**	-0.023 (2.04)*
Distance to towns (KM)	-0.0004 (1.27)	-0.0003 (1.05)	-0.0004 (1.20)
Loglikelihood	-7249	-7247	-7215
Pseudo R ²	0.09	0.09	0.1

All regressions include individual characteristics (gender, education, age), household characteristics (size, land ownership, asset ownership, electricity connection), village characteristics (if village has electricity, NGO programs, credit programs, market) and an intercept term as regressors.

Robust z statistics in parentheses

Significant levels: * = 5%, ** = 1%

Table 3: Urban access, Cash crop potential and Non-farm Employment: Non-Linear Effect

Dependent variable: Type of Employment in Non-Farm sector	Marginal effects Multinomial Logit regressions		
	(1)	(2)	(3)
<i>Wage employment-Low Return</i>			
Cash Crop Suitability Index	-0.032 (1.34)		-0.030 (1.03)
Cash Crop Suitability Squared	0.007 (0.94)		
Distance to Major cities (log)		0.011 (1.10)	
Distance* C. Crop Suitability		-0.003 (2.10)*	0.003 (0.67)
Test of joint significance (χ^2)	3.75	4.43	3.41
P-value	0.15	0.11	0.18
<i>Wage employment-High Return</i>			
Cash Crop Suitability Index	0.020 (0.38)		0.129 (2.90)**
Cash Crop Suitability Squared	-0.022 (1.23)		
Distance to Major cities (log)		-0.040 (3.11)**	
Distance* C. Crop Suitability		-0.006 (2.48)*	-0.033 (3.95)**
Test of joint significance (χ^2)	12.92	28.32	25.71
P-value	0.002	0	0
<i>Self-Employment</i>			
Cash Crop Suitability Index	0.057 (1.00)		0.049 (1.11)
Cash Crop Suitability Squared	-0.034 (1.82)		
Distance to Major cities (log)		-0.013 (1.04)	
Distance* C. Crop Suitability		-0.007 (2.38)*	-0.017 (2.16)*
Test of joint significance (χ^2)	12.4	13.19	13.41
P-value	0.002	0.001	0.001
Loglikelihood	-7228	-7207	-7218
Pseudo R ²	0.09	0.1	0.1

All regressions include individual characteristics (gender, education, age), household characteristics (size, land ownership, asset ownership, electricity connection), village characteristics (if village has electricity, NGO programs, credit programs, market), distance to town and an intercept term as regressors.

Robust z statistics in parentheses

Significant levels: * = 5%, ** = 1%

Table 4: Non-farm employment: Robustness check

	Type of Non-farm Employment		
	Wage employment Low Return	Self High Return	Employment
<i>Marginal effects: Multinomial regression1</i>			
Distance to Major cities (log)	0.021 (1.56)	-0.009 (0.51)	0.003 (0.19)
Distance* All Crop Suitability	-0.003 (2.09)*	-0.010 (3.19)**	-0.007 (2.30)*
Test of joint significance (χ^2)	4.36	32.8	11.45
P-value	0.11	0	0.003
<i>Marginal effects: Multinomial regression2</i>			
Travel Time to Major cities (log)	0.008 (1.04)	-0.048 (3.26)**	-0.018 (1.20)
Travel Time* Cash Crop Suitability	-0.002 (1.89)	-0.007 (3.17)**	-0.006 (2.64)**
Test of joint significance (χ^2)	3.79	26.7	11.74
P-value	0.15	0	0.003

All regressions include individual characteristics (gender, education, age), household characteristics (size, land ownership, asset ownership, electricity connection), village characteristics (if village has electricity, NGO programs, credit programs, market), distance to town and an intercept term as regressors.

Robust z statistics in parentheses

Significant levels: * = 5%, ** = 1%

Table 5: Non-farm employment: Alternative classification of nonfarm employment

	Dependent variable= type of nonfarm occupation		
	Factory Workers	Services Workers	Other Workers
<i>Marginal effects: Multinomial regression</i>			
Distance to Major cities (log)	-0.024 (1.88)	-0.002 (0.13)	-0.002 (0.17)
Distance* Cash Crop Suitability	-0.006 (1.90)	-0.011 (4.29)**	0.000 (0.24)
Distance to towns	0.0001 (0.32)	-0.001 (1.98)*	-0.0002 (0.87)

Regression includes individual characteristics (gender, education, age), household characteristics (size, land ownership, asset ownership, electricity connection), village characteristics (if village has electricity, NGO programs, credit programs, market), distance to town and an intercept term as regressors.

Robust z statistics in parentheses

Significant levels: * = 5%, ** = 1%

Table A.1: Summary Statistics

	Median	Mean	Std.Dev.	Min	Max
Probability of being employed in the following non-farm activity:					
High-return wage work	0	0.21	0.13	0	1
Low-return wage work	0	0.08	0.27	0	1
Self-employment	0	0.18	0.39	0	1
Occupation Category					
Production/Factory Workers	0	0.16	0.37	0	1
Services Workers	0	0.18	0.39	0	1
Individual & household characteristics					
Proportion Female	0	0.10	0.30	0	1
Age (year)	35	37.15	14.48	15	99
Years of Education	0	3.11	4.06	0	17
Household size	5	5.83	2.63	1	25
Per capita Agricultural land owned (hectare)	0.02	0	0.39	0	13
Total HH assets (1000 Taka)	61.25	129.28	276.39	1	7201
Proportion of household with electricity	0	0.20	0.40	0	1
Villages characteristics (Proportion of Village with)					
Electricity	1	0.65	0.48	0	1
Market	1	0.57	0.49	0	1
NGO programs	1	0.65	0.48	0	1
Credit Programs	1	0.87	0.35	0	1
Urban Access and Agricultural Potential					
Arc distance to Growth poles (KM)	121.4	134.80	76.53	1	367
Distance to nearest town (population>=5000) (KM)	36.24	42.89	31.28	1	207
Cash Crop Suitability Index	3.4	3.44	0.70	2	5
All Crop Suitability Index	3.8	3.80	0.64	2.4	5.1

Table A.2: Types of Nonfarm Employment: Multinomial Regression Results
Marginal effects reported.

	Dependent variable= type of nonfarm occupation		
	Wage employment		Self
	Low Return	High Return	Employment
Cash Crop Suitability Index	-0.0121 (1.84)*	-0.0439 (3.59)***	-0.0396 (2.80)***
Distance to towns (KM)	0.1089 (10.69)***	-0.0640 (2.57)**	-0.0650 (2.65)***
Female (yes=1)	-0.0015 (5.00)***	-0.0023 (5.82)***	-0.0005 (1.47)
Age (year)	0.0001 (0.11)	0.0213 (13.12)***	0.0033 (1.94)*
Education (year)	-0.0002 (0.13)	-0.0022 (0.82)	-0.0016 (0.52)
Household size	-0.0470 (1.80)*	-0.2342 (5.15)***	-0.1110 (1.80)*
Land owned per capita(hectare)	0.0000 (0.11)	-0.0001 (2.70)***	0.0002 (2.75)***
Total HH assets (1000 Tk.)	-0.0013 (0.09)	0.0679 (4.31)***	0.0587 (3.27)***
HH has electricity (yes=1)	0.0274 (2.22)**	0.0103 (0.51)	0.0265 (1.26)
Village has electricity (yes=1)	-0.0145 (1.04)	0.0533 (1.67)*	-0.0215 (0.82)
Village has NGO programs (yes=1)	0.0003 (0.02)	-0.0262 (0.67)	0.0672 (1.97)**
Village has Credit programs (yes=1)	0.0083 (0.77)	0.0161 (0.94)	0.0387 (2.19)**
Village has market (yes=1)	-0.0002 (0.84)	-0.0006 (1.79)*	-0.0004 (1.27)
Observations	6828		
log likelihood	-7249		

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1: Cash Crop Suitability Index

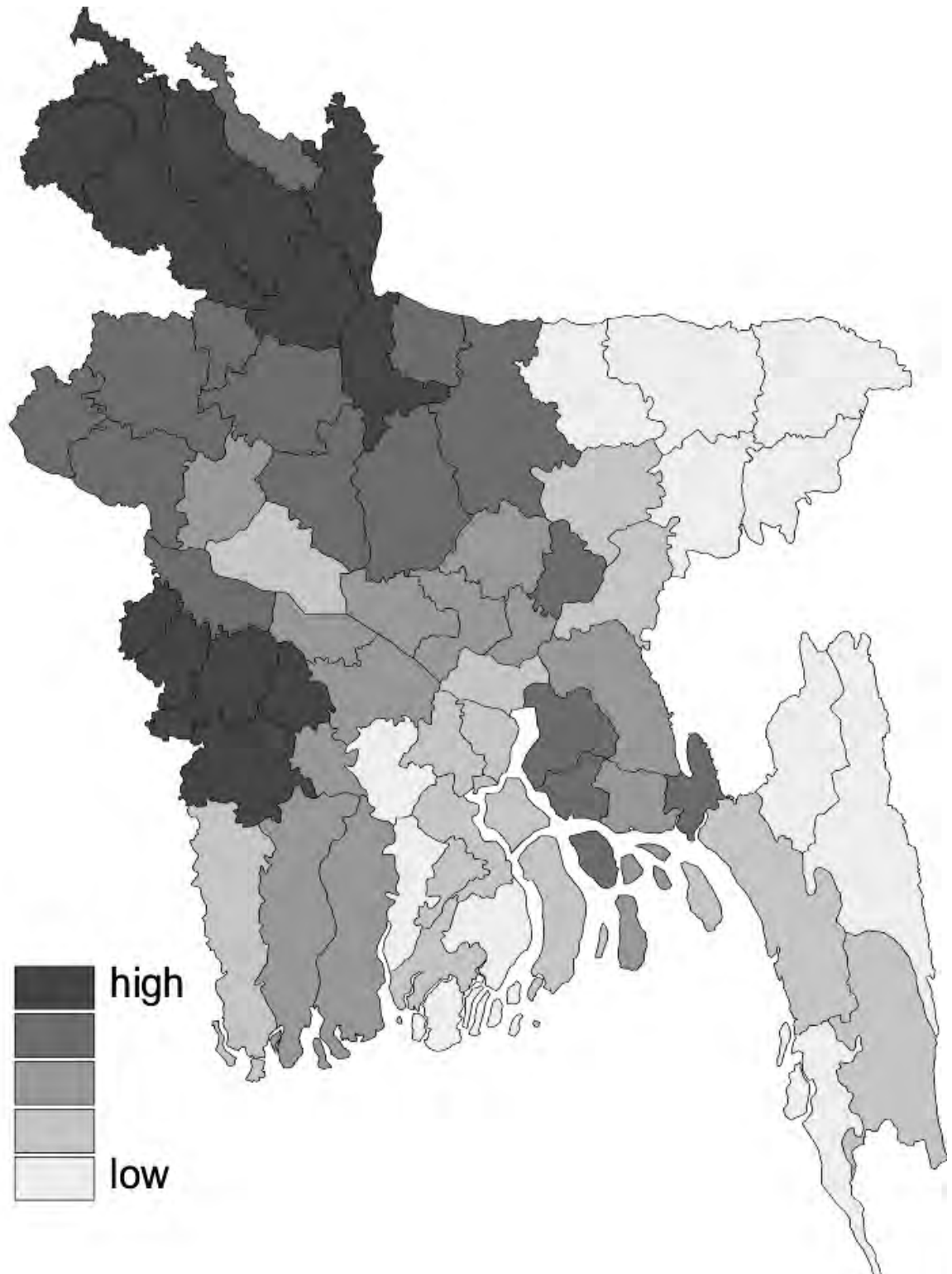


Figure 2A: Urban Access and Non-farm Activities

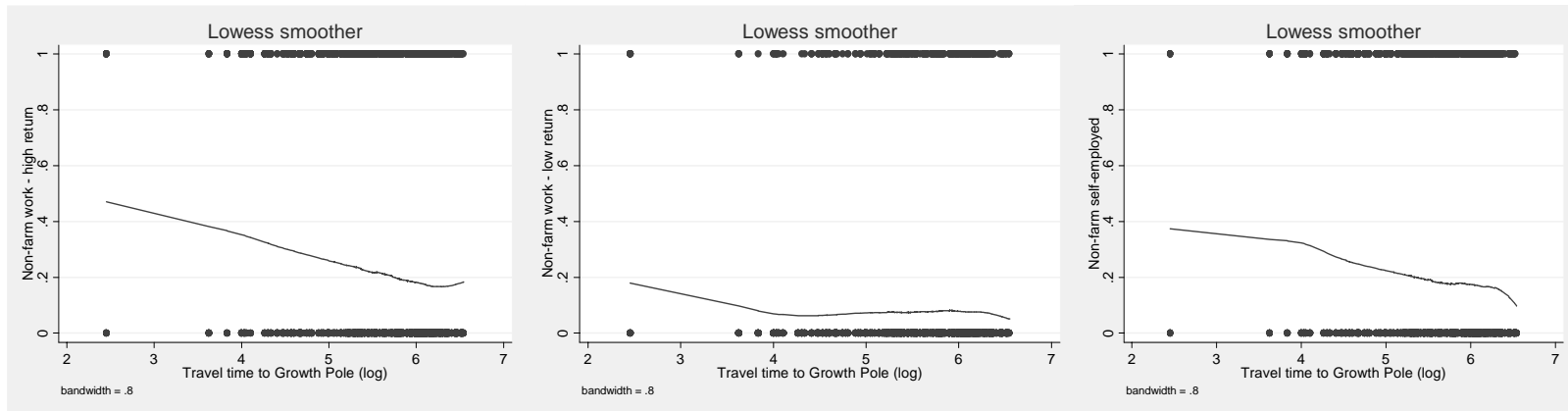


Figure 2B: Crop Suitability and Non-Farm Activities

